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*Andrew Gersey*

Dated

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*1. The method*



GB9805865.4

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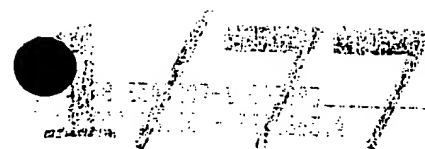
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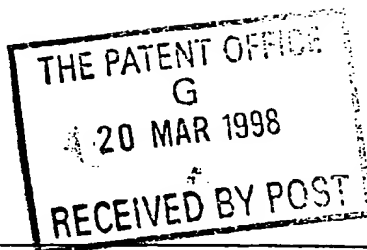
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3. Full name, address and postcode of the or of  
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Hill Hampton  
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SECTION 30

APPLICATION FILED 14-4-98

07209620001

4. Title of the invention

Moulded Article

5. Name of your agent (if you have one)

NIGEL BROOKS CPA

"Address for service" in the United Kingdom  
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11. I/We request the grant of a patent on the basis of this application.

Signature	<i>[Signature]</i>	Date
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### Moulded Article

The present invention relates to a method of forming an article via injection of plastics material into a mould.

5

In particular this invention is a second improvement on the invention described in our patent application No 9727107.6 of 23<sup>rd</sup> December 1997 ("the First Application"). That application reviewed the outlines of injection moulding, injection blow moulding and thermo-forming. In respect of the latter, it should here be noted that so called "plug-assist" thermoforming involves the use of a movable plug, which initial stretches the extruded sheet into cavities in the tooling prior to application of gas pressure to finally shape the material in the tooling.

The First Application stated the basic invention to be a method of forming a plastics material article, consisting in the steps of:

forming an injection moulded preform between core and first cavity mould parts,

separating the first cavity mould part from the preform,  
assembling a second, larger cavity assembly around the preform and  
blowing the preform away from the core part into a finished article shape.

Whilst the above statement refers to the withdrawn mould part and second, cavity assembly as "cavities", it is conceivable – though unlikely – that they could be convex.

25

The First Application continued with a review of the expected improvement in cycle time in comparison with the conventional injection/blow moulding process due to lack of indexing and reheating. It is anticipated that the cycle time will be of the order of 2.5 seconds, in comparison to a typical 5.0 seconds cycle for conventional injection blow moulding.

30

In the preferred embodiment of the First Application, which is set out below for comparison with and better understanding of the present improvement, the preform is stretched to reduce its average wall thickness by a third. This ratio could

be between a quarter and a half, but is unlikely to be substantially greater reduction in wall thickness. An important advantage of the basic invention is that it enables the initial wall thickness to be selected such that when moulded and stretched, the finished wall thickness can be predetermined to suit the end use of the product. Thus  
5 in comparison with a deep drawn thermoformed container, where the base is likely to be of the same order of thickness as the extruded sheet from which it was formed and the side walls will be drawn as thin as practical, a situation which creates a large disparity between the base and the side wall thickness and in wasteful of material in the base, the basic invention allows a much more uniform wall thickness. Further this  
10 thickness can be thinner than that which is practically achievable by injection moulding.

In accordance with an improvement, described in our patent application No 98008823.2 of 16<sup>th</sup> January 1998 (" the Second Application"), the preform is lifted  
15 from at least part of a fixed portion of the core part by a movable portion of the core part.

It can be appreciated that in the preferred embodiment of the basic invention, described in the First Application, this occurs to a negligible extent when the valve  
20 admitting pressurised gas is opened for blowing of the preform from the core, the end of the valve forming a portion of the core part.

In the improvement of the Second Application, the movable portion of the core part is moved to a substantial extent to stretch the moulded preform. The stretch  
25 will usually be in a selected region of the preform. Where the moulded article is a container with a base and a sidewall, the rim of the sidewall will usually remain attached to the fixed portion of the core and the base will be formed at the movable portion. The intervening sidewall will be stretched by forwards movement – downwards in respect of the orientation of the finish formed article – of the movable  
30 portion.

The forwards movement is likely to be accompanied by injection of low pressure gas into the container, to allow the sidewall to move off the fixed core portion without being held there by vacuum.

The attachment of the rim can be by polishing of the corresponding area of the fixed portion of the core. Alternatively or additionally, it can be captivated by the petals, in which case the movable portion is not moved until the petals are in position.

5 Otherwise the movable portion can be advanced before the petals are in position.

Similarly the periphery of the base can be attached to the movable portion, to limit the stretch in the base.

10 The movable portion can be moved forwards so far as to captivate the part of the preform on it between the movable portion and the corresponding portion of the petals. This has the advantage of enabling moulded features to be reproduced in the base – or equivalent part – of the article. For instance, the base may be formed in such a manner as to ensure that it stands stably without the centre being depressed.

15 Further this can have particular advantage in the case of plant pots, whereby drainage apertures can be moulded in (obviously the preform could not be blown without some means of obturating the drainage apertures).

The application of full gas pressure for finally blowing the preform to shape  
20 against the petals can be timed to start before the stretching by the movable portion has been completed. This is unlikely to be the case were part of the preform is to be captivated as above. Further the blowing can be timed to start before the petals are fully closed into position. However, it will normally be started after the petals have been closed. Air or a purified gas can be used for blowing. It may be cooled to assist  
25 in cooling of the blown article.

In the Second Application it was anticipated that a greater degree of wall thickness reduction would be practical with its improvement than with the basic invention.

30

The object of the present improvement is to further improve the basic invention and indeed the improvement of the Second Application.

In accordance with the present improvement, i.e. a Second Improvement, the preform is stretched by the movable portion of the core part to substantially the final shape of the finish formed article.

5        This enables the stretching of the preform resulting from the blowing step of the basic invention to be dispensed with.

It is anticipated that gas pressure will still be applied internally of the article to press the stretched sidewall(s) into contact with the petals of the secondary cavity, for  
10        cooling of the sidewall(s). However, lower pressure can be used.

The entire sidewall(s) may be stretched. Alternatively part, typically including a stacking feature, may be moulded to final shape in the preform and captivated in the petals before stretching, so as to avoid this part being stretched. Again, it can be  
15        envisaged that the stretching by the movable portion of the core part may be completed before final positioning of the petals, which are shaped to delimit a rim of the sidewall which can be blown – as in the basic invention – to larger diameter, enabling production of an overhang for instance for stacking.

20        The plastics material used in the invention may include blowing agent, whereby the sidewall(s) and possibly the base are allowed to expand by foaming. The resultant base and sidewall(s) will be stiffer, in comprising two interconnected skins, than if they were of the same amount of material provided as a thinner solid wall. Use of blowing agent enables a rim of the article and/or a de-nesting feature to be  
25        expanded by foaming.

According to another aspect of the basic invention, there is provided a mould tool comprising:

- a core part,
- 30        • a primary cavity part,
- a secondary cavity assembly,
- the secondary cavity assembly having a plurality of pieces movable from a withdrawn position allowing co-operation of the primary cavity part with

the core part to an advanced position defining a secondary cavity defining the outside shape of the finish formed article and

- means for moving the pieces of the secondary cavity assembly between their withdrawn position and their advanced position.

5

For the improvement of the Second Application and of the present, Second Improvement, the core part has a movable portion adapted to stretch a preform moulded between the core part and the primary cavity part to at least a region of the secondary cavity.

10

To help understanding of the invention, a specific embodiment thereof will now be described by way of example and with reference to the accompanying drawings, in which,

Figure 1 is a cross-sectional side view of a mould tool used in the basic invention as described in the First Application, with a primary cavity closed;

Figure 2 is a similar view of the mould tool with a secondary cavity closed;

Figure 3 is an end view, from the right in Figure 2, of the closed petals forming the secondary cavity;

Figure 4 is a cross-sectional side view of the preform of Figure 1;

Figure 5 is a similar view of the end product of Figure 2;

Figure 6 is a diagrammatic view of a tool modified in accordance with the improvement of the Second Application, with a preform injected;

Figure 7 is a similar view of the tool with the preform stretched by a movable portion of the core;

Figure 8 is a similar view of the tool with the preform blown to finish formed shape;

Figure 9 is a cross-sectional side view, similar to Figure 1, of a mould tool for the present, Second Improvement, with a primary cavity closed;

Figure 10 is a similar view with the primary cavity withdrawn, the second cavity assembly in its closed position and a movable portion of the core advanced to stretch the preform;

Figure 11 is a similar view of the preform as injected; and

Figure 12 is a similar view of the finish formed article. It should be noted that the wall thicknesses shown in Figures 11 and 12 are exaggerated for clarity.

Referring to Figures 1 to 5 of the drawings, the mould tool comprises a primary cavity 1, a core 2, a secondary cavity petals 3 and an actuation ring 4. The primary cavity 1 is attached to the fixed platen (not shown) of moulding machine in use and incorporates an injection gate 11, temperature control passages 12 and an  
 5 ejection poppet valve 13.

The core 2 is attached to the moving platen (not shown), has temperature control passages 21, a blowing air valve 22 with its own temperature control passages  
 10 23 and four pivot points 24 for the secondary cavity petals 3, of which there are four.

The petals 3 have their own temperature control passages 31. They are generally L shaped and pivotally connected to the core at the elbow 32 of the L, which is rather more open than a conventional L. The feet 33 of the L chiefly  
 15 comprise an "opening" surface 34, whilst the limbs of the L comprise a "closure" surface 35 on one side and a cavity surface 36 on the other side. They also comprise abutment surfaces 37 which mutually abut when the petals are closed to form the secondary cavity. Air bleeds 38 are provided.

20 The ring 4 carries four roller supports 41 having rollers 42 for co-operating with the opening and closure surfaces 34,35 and buffers 43,44. The ring is slidably supported on four bars 45.

In use, the ring 4 is withdrawn by a hydraulic ejection actuator (not shown) in  
 25 the direction away from the primary cavity 1 and the core 2 is advanced into contact with the primary cavity, as shown in Figure 1. The preform 5 shape so defined is for a cup. It has a wall thickness 51 of 0.3mm except at the rim 52, which is thicker for foaming expansion. Within 0.2 sec. of the end of the injection of plastics material through the gate 11 to fill the mould gap between the core and the primary cavity,  
 30 with a skin just formed against the cavity, the core 2 is withdrawn with application of air pressure to the poppet valve 13, whereby the moulded preform is withdrawn with the core.

As soon as the core is withdrawn sufficiently for mechanical clearance, the ring 4 is advanced. The rollers 42 leave the opening surfaces 34 and the forward buffers 43 knock the petals forward. The rollers then engage the closure surfaces 35 as the petals 3 swing closed about the pivots 24. The surfaces 35 have parallel ends 5 351, whereby when limit surfaces 45,39 on the roller supports and the petals engage, the petals are firmly held closed, see Figure 2. This position is reached within 0.5 sec. of core withdrawal, whereupon gas – suitably nitrogen at 40 bar – is blown through the valve 22 and the preform is expanded into the secondary cavity, to take up the shape 6 of the finished product. It should be noted that the petals have a groove 361 for 10 allowing the rim 52 to expand. The typical wall thickness of the finished product is 0.2mm.

Immediately after blowing, the ring 4 is withdrawn, the rear buffers 44 knock the petals open and product falls from the tool. The latter can now close again for the 15 next cycle. The total cycle time is expected to be 2 ½ seconds.

Temperature control is important – as always in injection moulding. It is to be expected that the primary cavity and the petals will be run cold, respectively to cause the preform to skin and allow early opening and to cause the blown product to 20 become rigid for early opening of the petals. However, it is expected that the core will be run warmer, so as to allow the preform to be in a state able to expand plastically when the gas is blown into the mould tool.

The basic invention is not restricted to the details of the above described 25 embodiment. For instance the finished product as described is a circular cup. However, a rectangular container can be made by the method of the invention. For such, the four petals, shown in Figure 3 as meeting in a cross formation, may meet in a double/stem-to-stem Y formation, that is with two petals abutting at the stems of the Y's and two other petals having points filling the gaps in the heads of the Y's. 30 Further more or less than four petals may be provided. Further for products having particularly vulnerable areas, such as corners, the wall thickness of the preform may be varied in areas stretching into the vulnerable areas, to reinforce them. This may involve thickening of adjacent areas to encourage stretching there, leaving the areas to be reinforced less stretched.

Referring now to Figures 5,6 & 7, the mould tool diagrammatically shown there comprises a primary cavity 101, a core 102, and a secondary cavity petals 103, which are essentially similar to the primary cavity 1, the core 2, and the secondary cavity petals 3. The exception is that the core is shaped as a truncated cone and comprised of a fixed portion 1021 and a movable portion 1022. At the proximal end of the core, the fixed portion has a narrow polished band 1023, whilst the balance of its length 1024 is matt finished as by bead blasting. The movable portion 1022 is of the same diameter as the distal end of the fixed portion and mates with it in the manner of a conical valve, whereby injected plastics material cannot enter between the portions, whereas the portions are readily separable by an actuator (not shown) for stretching of the preform 105 and egress of pressurised gas from within the core. The movable portion 1022 is relatively short in comparison with the fixed portion and is in the form of a disc with a matt radiused corner 1025 and a polished ring 1026 on its end face. Within the ring 1026, the movable disc has formations 1027 which together with formations 1017 in the cavity and formations 1037 in the ends 1033 of the petals form apertures 1061 and feet 1062 in a base 1063 of the finish formed article, which is a plant pot 106. It has sidewalls 1064.

On closure of the primary cavity 101 by the core 102 and injection of plastics material into it, the preform 105 is formed. The primary cavity 101 is withdrawn and the petals 103 are closed around the core and the preform. The movable ring 1022 is then advanced. In so doing, it axially stretches the preform between the polished banded 1023 and the polished ring 1026. At these polished areas, the plastics material is held onto the metal of the core, whereas it lifts from the metal at the intervening matt region 1024. In so doing a gap is opened between the plastics material and the core. This is filled with low pressure gas released as the movable disc is advanced, whereby the material is stretched without being influenced by unintentional stiction with the fixed portion 1021 of the core.

On completion of the forwards movement of the movable ring 1022, the plastics material within the polished ring 1026 is carried forwards into contact with the petals 103 and the features formed by the cavity formations 1027 are mated with corresponding petal formations 1037, whereby as the material fully cools the base

1063, with its apertures 1061 and feet 1062, sets off. As soon as the ring has reached this end of its stroke, higher pressure gas is released from the core, causing the stretched side wall 1064 to be expanded out circumferentially to the sides 1034 of the petals. At the radiused corner 1025 of the ring, the material rolls and is stretched into  
 5 the corners 1035 of the petals.

It will be appreciated that although the improvement has been described with reference to a plant pot, it is applicable to a wide variety of finish formed products. In particular, the sidewalls of the petals can be contoured to provide contoured sidewalls  
 10 to the finish formed product.

Turning now to Figures 9 to 12, the mould tool there shown for the present Second Improvement comprises a primary cavity 201, a core 202, a secondary cavity assembly 203 and an actuation ring 204. The primary cavity 201 is attached to the  
 15 fixed platen (not shown) of moulding machine in use and incorporates an injection gate 211, which preferably is a mechanical valve shut off gate.

The core 202 is attached to the moving platen (not shown) and has a fixed portion 2021 having outside its preform shaping surfaces 20211 four pivot points 224  
 20 – of which two are shown - for the secondary cavity petals 2030, of which there are four. Also the core incorporates a movable portion 2022, comprised of a preform shaping end plate 20221, a carrier 20222 for the end plate, a pair of movement rods 20223 to which the carrier is attached and which are housed in bores 20224 in the core 202 via linear bearings 20225. The rods are reciprocatably movable by the  
 25 hydraulic ejector actuator of the moulding machine, not shown. The end plate 20221 and the fixed portion 2021 have bevelled surfaces 20226 which seal under injection pressure. Centrally of the bores 20224 is a gas introduction passage 20227.

The core also has an ejector ring 20228 and a plurality of pneumatic actuators  
 30 20229 therefor.

The petals 2030 are generally L shaped and pivotally connected via the pivot points 224 to the core at the distal ends of the long limb 2031 of the L. The long limb and the short limb 2032 have respective article shape definition surfaces 2033, 2034.

The petals are connected to the actuation ring 204 via connecting rods 2036 pivotally connected to the ring and the petals via respective trunnions 2037. In the withdrawn position of the ring 2035, the petals are swung away from the core. In the advanced position of the ring the petals are swung over the core, when of course the primary cavity 201 has been withdrawn from the core. In this position the petals assemble to form a secondary cavity. It should be noted that the three dimensional shape of the petals and the article is not shown in the drawings. However, it can be rectangular, circular, oval or other shape.

Turning now to Figure 11, the preform shape 205, as defined by the core 202 – including the end plate 20221 – and the primary cavity 201, is there shown. It should be particularly noted that in the normal course of events, the preform will not be made as a solidified article. It is formed by initial injection and is finally shaped before it has solidified to final shape. However, its injected shape is important. It comprises:

- a rim 2051, whose shape will be described in more detail below,
- a stacking step 2052,
- a sidewall 2053, which is thicker than the stacking step, and
- a base 2054 with a raised central portion 2055, the base having the same thickness as the stacking step.

The plastics material with which the article is to be formed has a blowing agent incorporated in it.

Immediately after injection and on solidification of the outer skin of the preform, the primary cavity is withdrawn. Simultaneously three events then occur:

- The pneumatic actuators – not shown – are actuated, to cause the petals to swing in;
- The hydraulic ejector actuator of the moulding machine – not shown – is actuated, to move the end plate 20221 to carry the base 2054 towards the base surfaces 2034 of the petals; and
- Pressurised gas is introduced within the preform via the passage 20227.

The result is that the sidewalls 2053 are stretched to their final height. The stacking step 2052 is not stretched, partly because it is moulded on a polished core surface and

partly because it is captivated by the petals. The base is not stretched because it is simply carried forwards on the end plate 20221. Both these elements of the finish formed article remain as moulded in the preform and are cooled by the respective parts of the tool with which they are in contact.

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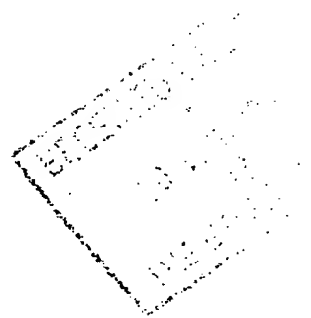
The sidewall is unrestrained as it is being stretched, except that there is low pressure gas within the preform, which is of such pressure to urge the sidewall into contact with the petal side surfaces 2033 once the stretching is complete. However, prior to this, the sidewall is relatively unrestrained. Its initial thickness is greater than that of the stack step. Immediately before the end plate is moved forwards to stretch the sidewall, there is short delay. Internally the sidewall has molten plastics material with blowing agent, which causes the inner and outer skins of the sidewall to separate, creating a foamed structure therebetween. Once this separation has occurred during the delay, the two skins are stretched by movement of the end plate. This draws the skins straight and reduces their separation due to the action of the blowing agent. When the outer skin comes into firm contact with the side surfaces 2033, due to the action of the internal pressure, the action of the blowing agent is quenched by solidification of the sidewalls, the petals being internally cooled. The final thickness of the sidewall is controlled by the gas pressure applied via the passage 20227 acting to counterbalance the internal foaming gas pressure.

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15  
20

The rim 2051 has a flat top 20511, formed by a recess in the ejector ring 20228. The underside of the rim as formed in the preform by the primary cavity has a narrow channel 20512 adjacent to the stacking step and broader channel 20513 with a thicker wall. The edge of the rim 20514 tapers down from the top 20511 as a de-nesting feature. When the rim is enclosed by the petals, it is restrained to have a flat underside 20515. The thick wall of the broader channel 20513 expands by foaming with its skin length remaining substantially constant. The result is that the narrow channel closes and the resultant rim has a uniform depth, giving it considerable stiffness. This effect is in accordance with our International application No. PCT/GB96/01706.

25  
30

Once the article has been cooled in its finished shape, the petals are opened, and the ejector ring 20228 advanced to eject the product from the tooling. The tool can now be cycled again.



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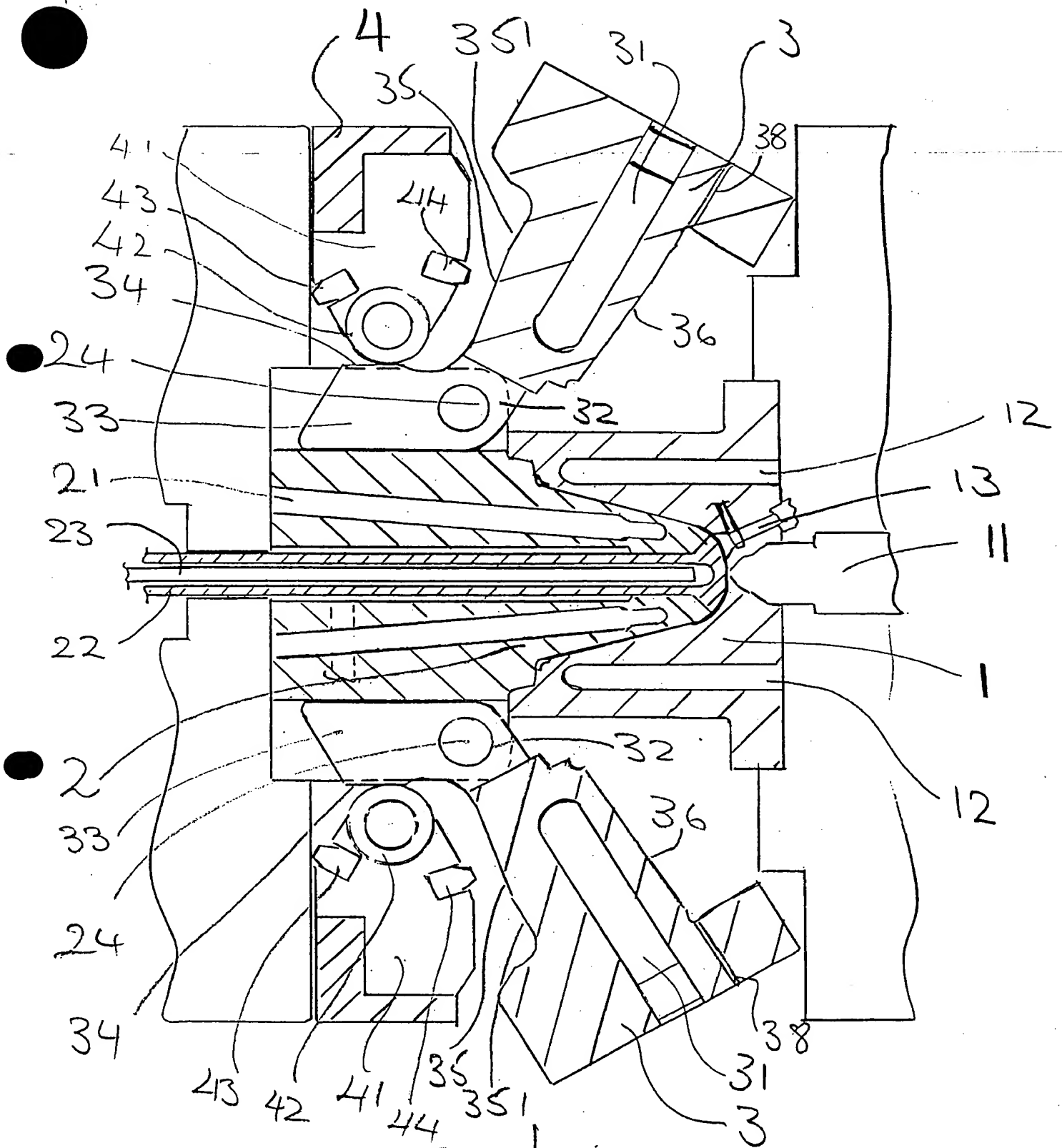


FIGURE 1

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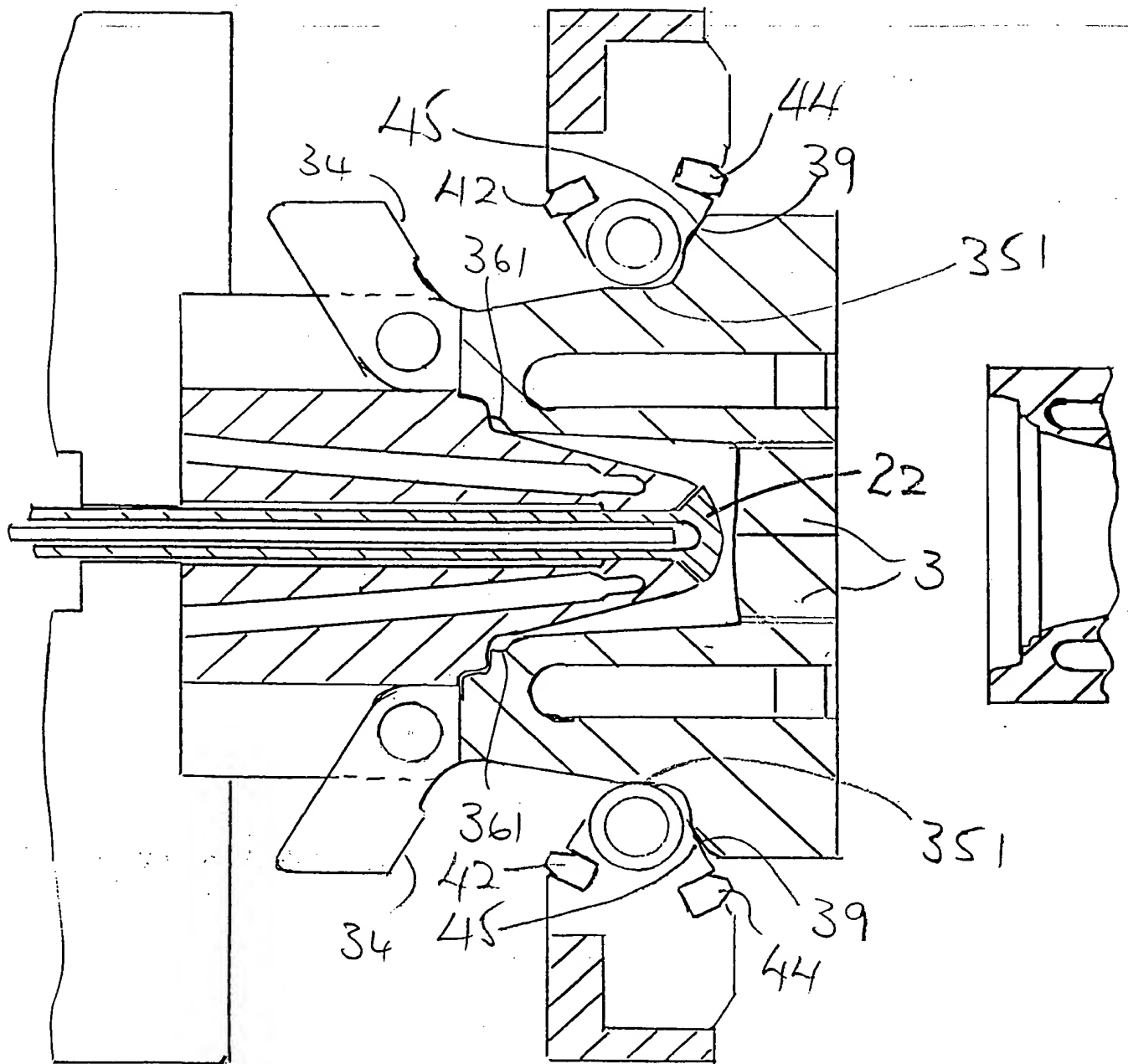


FIGURE 2

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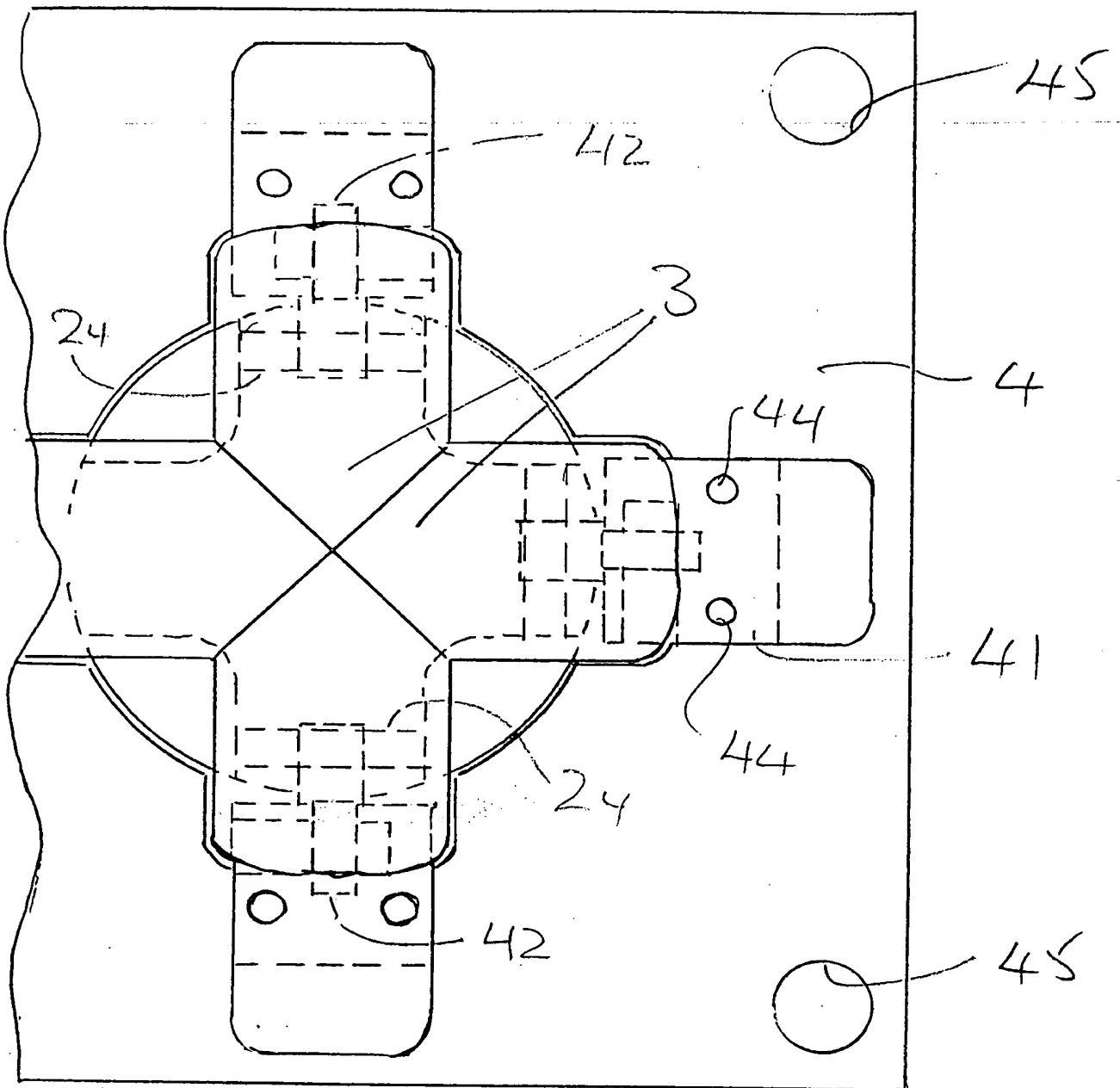


Figure 3

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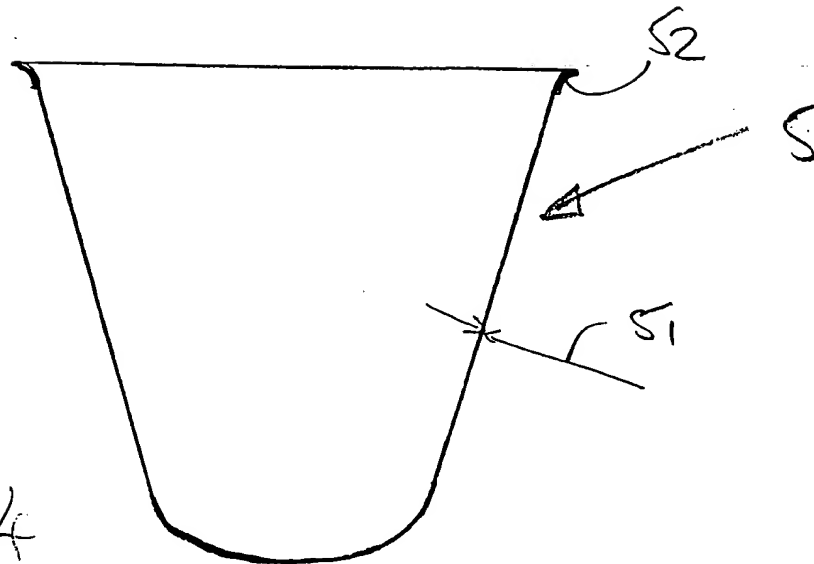


FIGURE 4

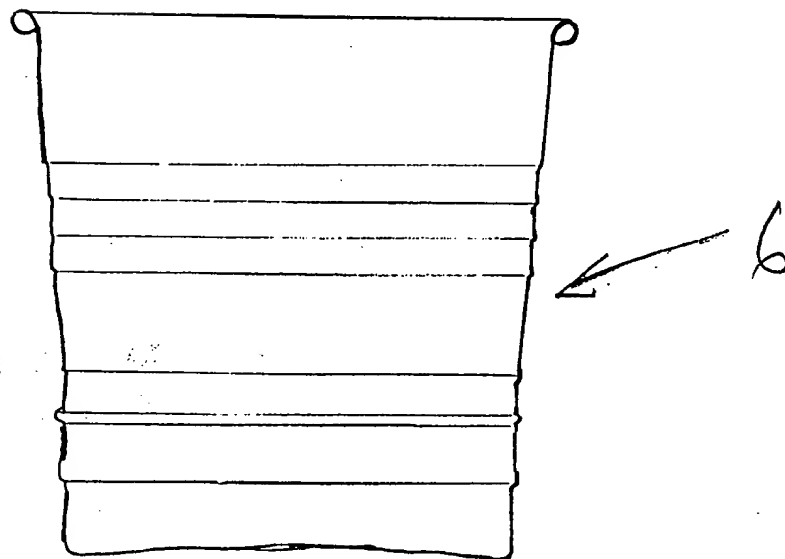


FIGURE 5

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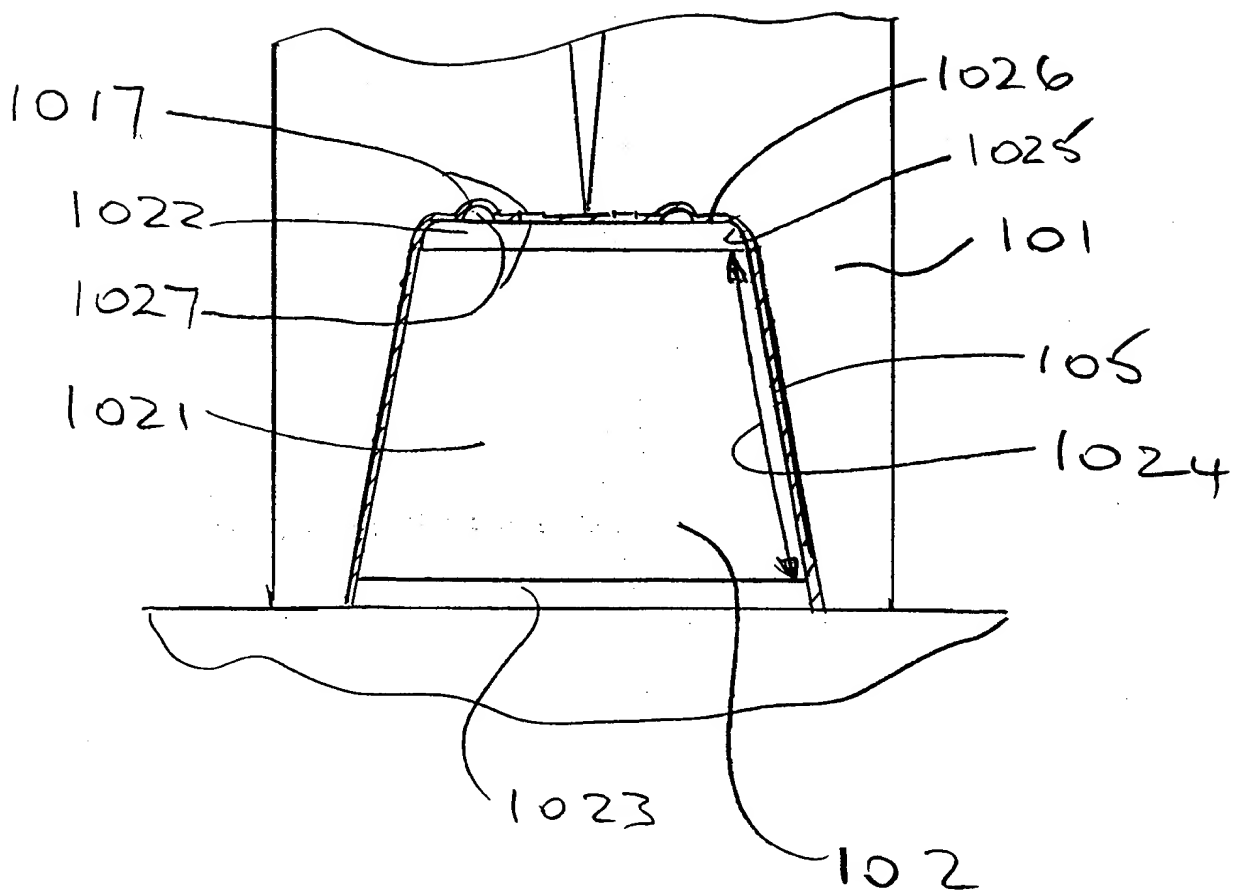


FIGURE 6

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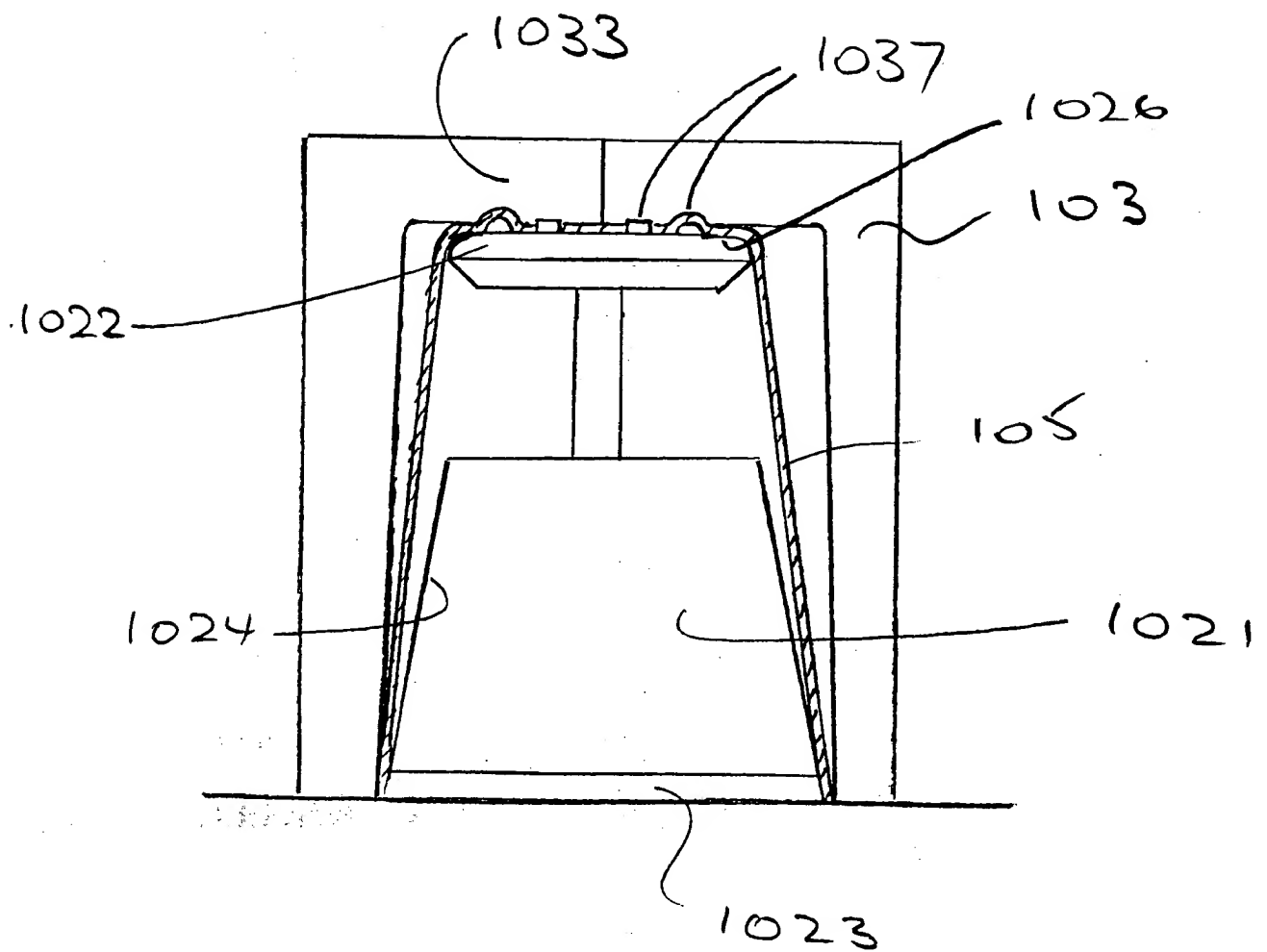


FIGURE 7

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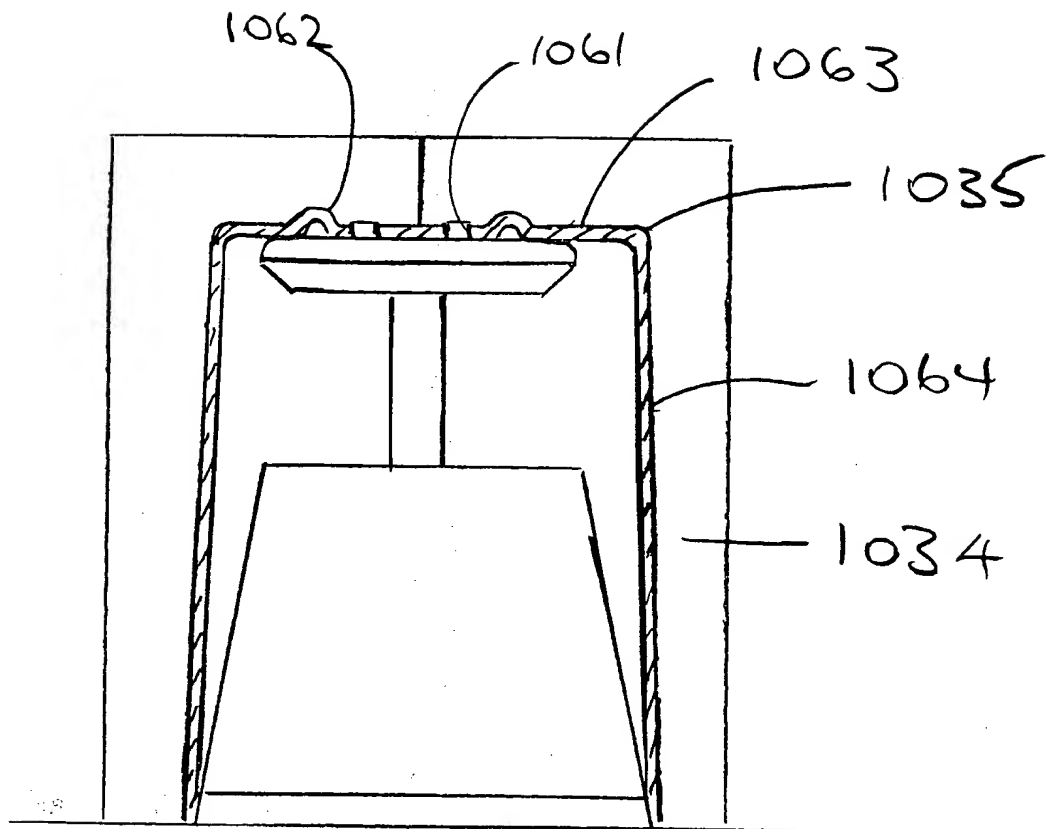


FIGURE 8

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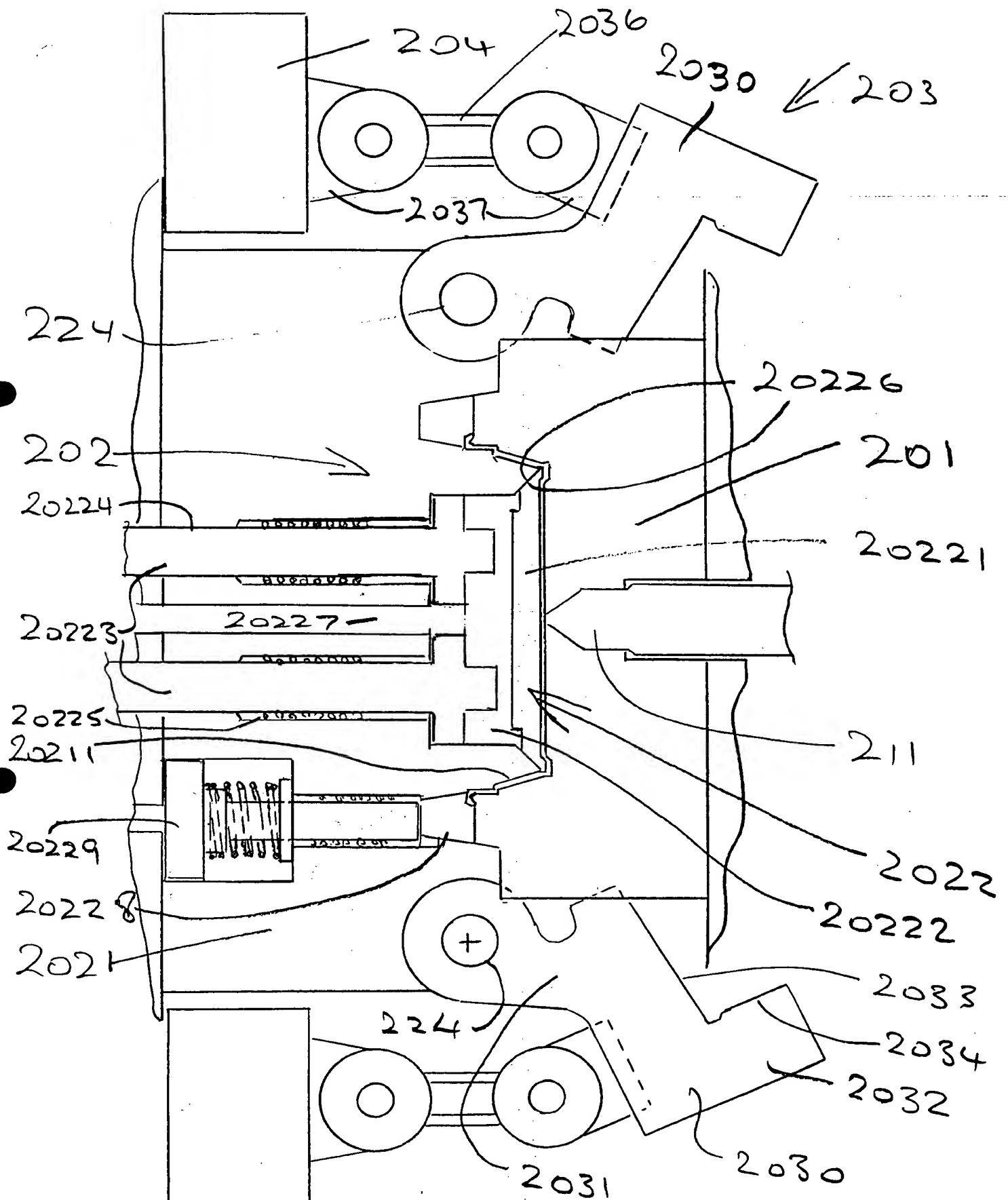
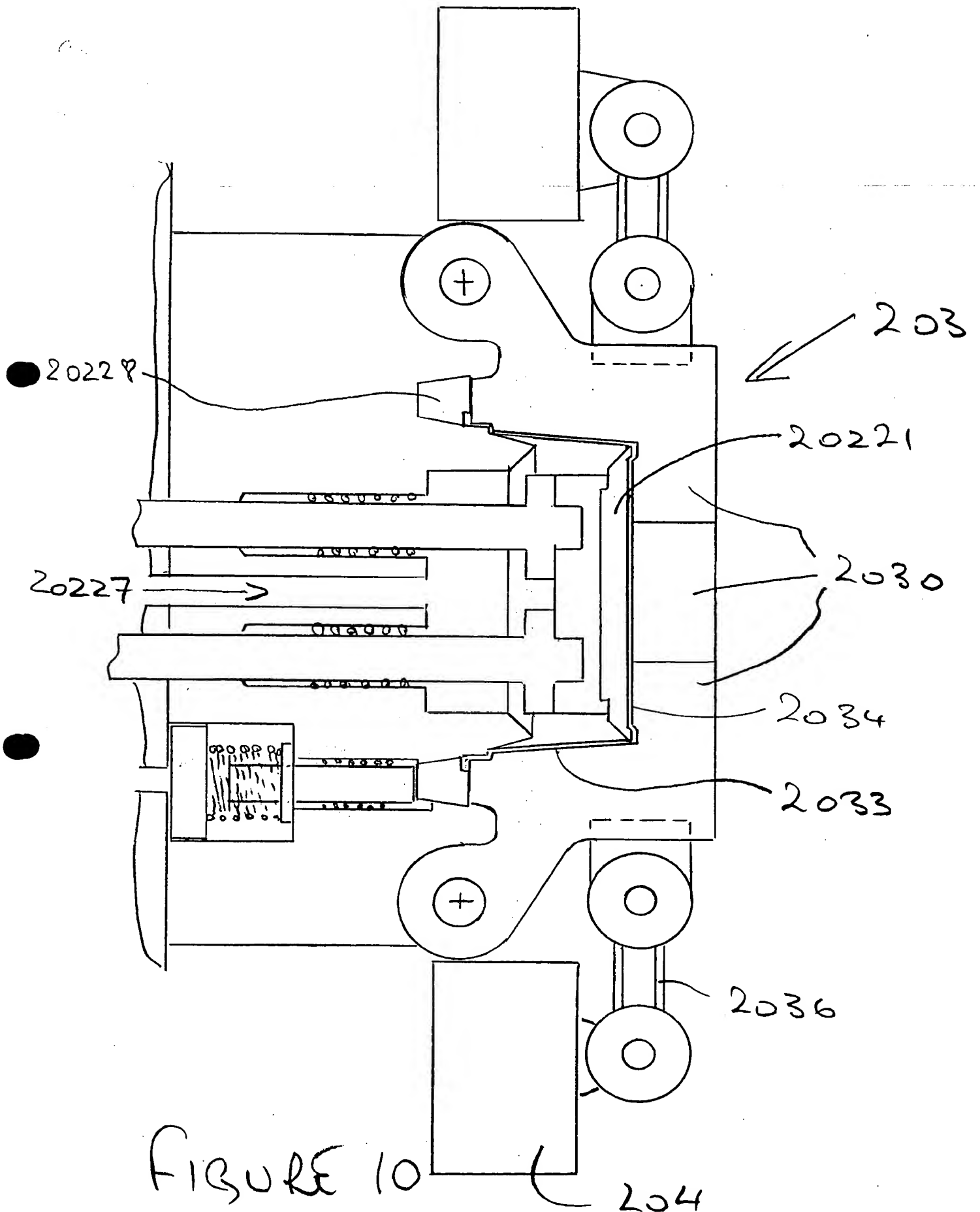


FIGURE 9

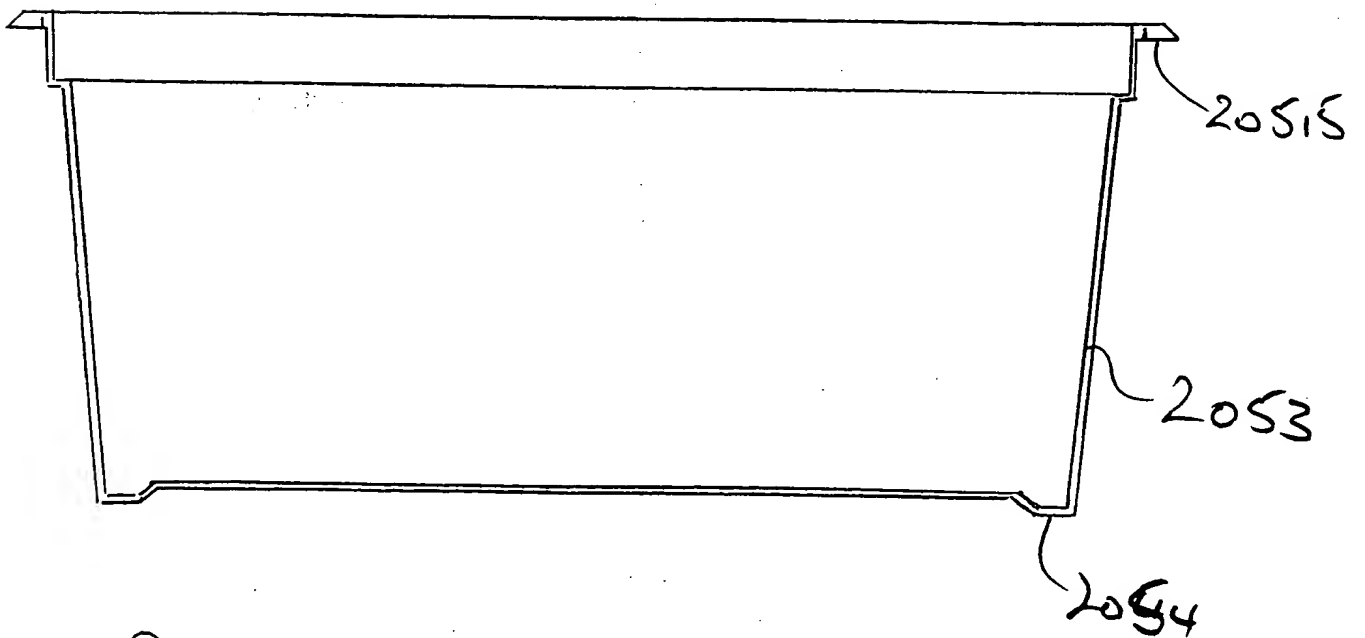
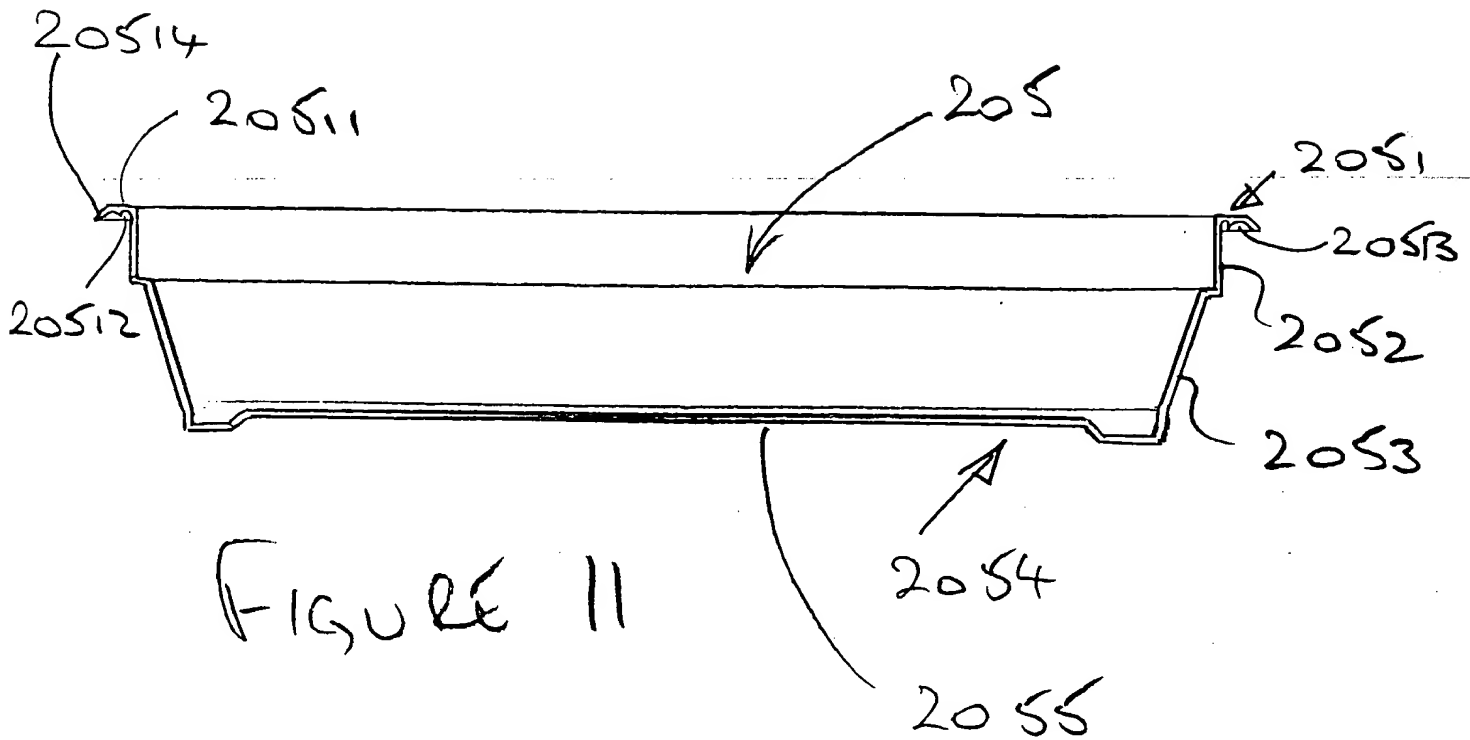
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Nigel Brooks